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ABSTRACT

This document describes some of the experience gained from an evaluation of Du-It, an experimental Industrial Technology Branch program affiliated with the Production and Maintenance Engineering Line (Du-It) of upper secondary school being conducted at Trollhattan, Vasteras, Karlskrona, Harnosand, and Goteborg upper secondary schools. As with similar projects underway in Sweden, Du-It is aimed at qualifying students for new vocational roles in an industrial environment dominated by advanced technology. Major findings are that the Du-It program is closely attuned to the present and future labor requirements of the engineering industry but that it may lack a more perceptible link with the ideas of group work organization that permeate Swedish industry and that require some training in administrative and economic routines, problem formulation, and problem solving. (Laboratory work using production equipment may provide these aspects, but program developers should safeguard creative potential by not overprogramming laboratory activities.) In addition, the program lacks elements that relate to the quality of the products produced. Employers hired the majority of program completers into relatively unskilled jobs, and students were disappointed. It is important that the program remain up-to-date in equipment and content. (CML)

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SCHOOL RESEARCH NEWSLETTER

AUGUST 1989 FIELD-TOPIC 1989:5

Interaction between education,
the labour market and working life

Concluded project:
EVALUATION OF EDUCATION FOR INDUSTRY

Education for industrial employment of tomorrow

Developments during the past decade in the engineering and process industries have created a need for new occupational groups and new study programmes.

In respons to this need, The National Board of Education has tried to modernise vocational studies in the vocational lines, i.e. study programmes, of upper secondary school. Attempts of this kind have, for example, involved the Production and Maintenance Engineering Line (an experimental Industrial Technology Branch), the Metalwork Line (experimental supplementary courses in automation techniques) and the Process Engineering Line (an experimental integrated study programme for grade 2).

In addition, there are the experimental activities involving a three-year Industrial Technology Line, inaugurated in the autumn term 1987.

All these experiments share the basic idea of education qualifying the students for new vocational roles in an industrial environment dominated by modern, advanced technology. Key words in this technology are robots, NC machinery, flexible manufacturing systems (FMS), automated warehouses and computerised production systems.

In this issue of the School Research Newsletter, we will be describing some of the experience gained from an evaluation of an experimental Industrial Technology Branch affiliated to the Productional and Maintenance Engineering Line (Du-it) of upper secondary school. These experimental activities are being conducted at Trollhättan, Västerås, Karlskrona, Härnösand and Göteborg upper secondary schools.

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Theoretical vocational education

The Production and Maintenance Engineering Line (Du) was established in the 1970s, in response to pressure from the electric power industry, the big housing utilities and representatives of the heating, ventilation and plumbing sector. Maintenance questions were judged so vital in these sectors as to require a special study programme. One fundamental idea was for studies to focus on **systems**, not on components or individual machines.

The Production and Maintenance Engineering Line is of two years' duration, with a common foundation course in grade 1. Then, in grade 2, studies divide into the Power Production Branch, the Marine Engineering Branch, the Electrical Power Production Branch and - the branch now under consideration - the Industrial Technology Branch.

The Industrial Technology Branch (it), which began in 1985, is intended to train operating technicians with a certain measure of servicing responsibility, which means that, in addition to keeping machinery productive, they have to perform a certain amount of programming, supervision, quality control, fault diagnosis and remedial and preventive maintenance. The new operator role does not supersede that of previous experts such as mechanical engineers, electricians and electronics engineers but is to be looked on as supplementing those categories. Compared with the two-year Metalwork Line, the Production and Maintenance Engineering Line includes a substantial quantity of theoretical studies. English and mathematics are compulsory, which they are not in the Metalwork Line, and there is also a much larger element of vocational theoretical studies.

Compared with the first two years of the four-year Technology Line, the theoretical elements of the Production and Maintenance Engineering Line are on a smaller scale and are more concerned with applied knowledge. The first two years of the four-year Technology Line, for example, include twice as much mathematics. Swedish, English and mathematics follow the same syllabi as in the two-year Economics and Social Lines. Work experience shares the same syllabus as the corresponding subjects in two-year vocational lines.

The syllabi for grade 1 of the Du line are the same for all specialities. The Industrial Technology Branch, in other words, does not diverge until grade 2. In keeping with this common first-year programme of studies, the component courses are of considerable breadth.

Students have the use of advanced laboratory equipment, in the form of a small production system comprising a CNC lathe, an industrial robot, an automatic magazine, an auto-truck and a multiple conveyer system. The system is of the "limited manning production" type and can simulate an FMS system. The system is adapted to automatic production of small parts.

The purpose of this advanced laboratory equipment is for the students to practise on equipment which is both modern and realistic and which is of a kind which they will be meeting subsequently in their working lives. The laboratory work has to confer certain technical skills.

The transformation of working life

We have studied the new production engineering concepts which have made their appearance in the Swedish and international engineering industries and, to some extent, in research as well. Our impression is that Swedish and international developments are to a great extent moving parallel as regards production engineering and work organisation. Where Swedish developments are concerned, we find that the main industrial corporations are unanimous in their views concerning the production concepts of tomorrow's industries. Small companies present a more inchoate picture. One thing which they have in common is their role of sub-contractors, which makes them heavily dependent on larger companies.

There are four main lines of development capable of affecting the development of skills in the labour force:

- The market connection is growing more important.
- Capital commitment is increasing.
- Automation is increasing.
- Quality questions are growing more important.

The growing importance of the market connection is manifested by the increasing customisation of production, and by the increasingly rapid replacement of product models. In terms of production engineering, these developments imply a more flexible production apparatus, frequently combined with a decentralised production set-up. Medium and small industrial concerns have previously shown more flexibility in adapting to changes in the market and to the special needs of different customers. Modern production technology has now made it possible for larger, mass-producing companies also to adapt their production to customers' needs. Flexible manufacturing systems (FMS) have been a key factor in this evolution.

These developments may entail a re-structuring in favour of a larger proportion of big companies, with the remaining small businesses tending more and more to become sub-contractors.

The Institute of Production Engineering Research (IVF) is one of various Swedish organisations basing their activities on a pronounced FMS concept. As IVF sees it, however, the step from an FMS cell to the vision of the unmanned factory is a very long one. The FMS concept now being introduced in the engineering industry will require many engineers and operators.

Another way of achieving greater flexibility is by adopting a group organisation concept. With Volvo, flexibility is something of a key concept, and group-organised production is looked on as one of its prerequisites. Flexibility in this connection refers to the ability both to adjust to fluctuations in output volume and to changing preferences of the market with regard to product design.

The growing amount of capital tied up in industry is having two effects:

- Increasing demands for shift work.
- Increasing demands for availability.

In industry, the possibilities are being discussed of minimising the proportion of the workforce having to go on shift work. The new technology presents certain opportunities in this respect, in the form of various systems for limited manning production. The growing demand for

availability has caused increasing attention to focus on the question of workforce qualifications. Many people have testified to the need for skilled labour in this respect and have drawn attention to the necessity of developing and improving vocational education. The question, as far as they are concerned, is whether vocational education is to be specialised or whether, on the contrary, it should confer knowledge of a general kind. In the Swedish debate there is a clear preponderance of opinion in favour of general qualifications.

The engineering industry's own research institute (IVF) stresses the need to take into account differences, e.g. in the sizes and manufacturing specialities of individual companies. To cope with these differences we need a more generalised form of engineering education than we have today. Björn Svedberg, President of the Ericsson Group, is one of those who advocate general study programmes with a central position allotted to the basics of mathematics, physics and languages. Some of the specialisation, in his opinion, must be left to companies themselves. Another, frequently emphasised aspect of general qualifications is a knowledge of problem analysis, knowledge of work organisation methods and similar, more general skills. What is wanted here is a labour force capable of organising its own knowledge.

A third aspect, also touching on the question of general qualifications, is the importance of a company being able to keep abreast of technical progress with its existing employees. We have encountered the view that, if this cannot be accomplished, industry will have to change employees at roughly five-year intervals. A workforce with general qualifications, trained in problem analysis and problem-solving, would have less difficulty in coping with the necessary re-adjustments.

In the international debate on education it has been emphasised that, in future, study programmes will be needed which include both electronics and mechanical engineering, instead of treating the two subjects apart. In other words, the call is for study programmes resembling Du-it or the Electrical Engineering Branch as part of an Industrial Technology Line. One important aspect of the growing demand for availability is the need for a highly trained workforce capable of maintaining the technical system. The question here is how far one should go in the matter of

specialisation. It is above all Volvo and Saab who have taken action and framed a policy on these questions, tying in very closely with the Du-it concept of operators with a certain amount of maintenance responsibility and drawing attention to the possibility of reducing specialist maintenance inputs in the workshops. Volvo Aircraft Engines, for example, aims to have 60% of all faults rectified by its own operators.

There are two sides to the discussion of the rising level of automation: a purely technical one, with discussions of different solutions, and a labour-oriented side concerned with the impact of automation on human work. To take the example of automative industry, two different paths of development can be discerned in production engineering. One of them means designing parts which can be put together by robots and automated equipment. The other means designing the car in such a way that its various components will be suitable for assembly by more or less autonomous production groups. In this respect, Saab and Volvo are an example to many other motor manufacturers.

As a parallel development, more and more advance assembly can be done, instead of all operations being performed on the assembly line. The first-stage sub-contractors are required to deliver a complete package, and in this way production is broken down into product workshops or sub-lines. As regards the societal effects of automation, the big question is its impact on unemployment. Industrial spokesmen usually reply, as one voice, that a rising degree of automation means a growing number of job opportunities. In an international perspective, this can seem contradictory, because there are several countries where job-sharing/working hours reductions are being discussed as a possible strategy for counteracting the unemployment which new technology is expected to entail.

In the ongoing discussions of product quality, we wish to point out that the quality concept incorporates an important social component and that various kinds of quality audit programmes are going to become increasingly important as time goes on. We have often heard it said that involving employees at shop-floor level in problem solution, not just in problem identification, is sound economics.

Quality questions can force industry into an extensive delegation of responsibility. Quality circles in various forms are being discussed all over the world, and the participation debate has also come to life in the USA. In Sweden, ideas relating to group work and up-skilling concepts have predominated for a time. Decentralisation of productive responsibility is sometimes viewed as a prerequisite for coping with quality questions.

The business idea of ASEA Robotics, for example, is flexible automation as a means of obtaining high product quality. FMS techniques are there being combined with quality issues within the framework of an extensively implemented group organisation.

Corporate recruitment philosophies

We have studied the views taken by a sample of Swedish companies concerning their future labour requirements. What sort of labour do they prefer and how do they go about recruiting it? One is above all struck by the wide diversity of the answers received. Companies are confronted with problems of various kinds, depending on the situation in which they find themselves. We have, however, been able to identify a number of general characteristics.

Corporate size does a great deal to influence the recruitment philosophy applied. Large companies like Saab, Volvo, ASEA and Ericsson have a wide recruitment base. Where these companies are concerned, educational background is not critical. Instead they recruit employees both from two-year upper secondary school lines and from the four-year Technology Line. Nor do they exclude the possibility of recruiting applicants with no technical qualifications. Engineers from the four-year line can, initially, be put on simple assembly-line work and regarded as a kind of skill reserve. In some cases this placement forms part of a training programme for trainee engineers. These companies have invested considerable resources in further training for their employees.

Small companies, on the other hand, must have a labour force tailored exactly to their production and machinery. Their machine line-up may be quite sophisticated, but they do not recruit engineers from the four-year

Technology Line. Instead they want experienced skilled workers. These companies do not feel they can afford to finance their own up-skilling.

Comparing the views taken by personnel officers of applicants' educational qualifications, one finds there are great differences. The personnel officers know a great deal about the way in which the educational system is organised. They know, for example, that there is such a thing as a Production and Maintenance Engineering Line, and most of them also know about the Industrial Technology conclusion. They have a clear idea of the advantages and disadvantages of each study programme. Personnel officers emphasise the growing importance of education in future industrial production.

Production engineering managers share the personnel officers' view concerning the growing importance of the educational qualifications of the labour force for the future. On the other hand they do not know how the educational system is organised, and they speak in more general terms, e.g. of technical and social studies or of two-year and four-year study programmes.

Foremen, who in practice are often the people who decide whether or not an applicant gets the job, are poorly informed about the existing educational routes. As a rule they distinguish only between two-year and four-year study programmes, and in the case of two-year programmes between engineering and electrical/telecommunications engineering programmes. Foremen put widely varying values on the educational backgrounds of newly recruited employees. Some of them prefer employees with a two-year background, while others prefer the four-year technical study programmes. Generally speaking, education means less to foremen than to personnel officers and production engineering managers. On the other hand, foremen seldom have much choice. They often feel that they have to take whatever labour is going, i.e. the people referred to them by the personnel department.

Education must lead to a job

Compared with previous study programmes, Du-it will have to confer dual qualifications. On completion of the study programme, the student must be

able to start work both as an operator and as a maintenance employee. Compared with the Metalwork Line, demands concerning basic machining skills are pitched low. It is sufficient for the Du-it student to have a knowledge of the principles of chip-forming and plastic machining. No actual skills are demanded. The emphasis instead is on the system level, and laboratory instruction is expected to confer certain technical skills. The maintenance competence to be acquired by the students is defined in such a way that they must be able to diagnose faults and themselves rectify electrical and mechanical faults of a fairly simple nature. Rectification of electrical faults can take place within the scope of "limited electrical trades authorisation". The research material does not specify the length of the induction period needed prior to vocational placement.

In our evaluation we followed the progress of the first year of students into the employment sector. Out of a total of 47 students, 26 entered employment while the remaining 21 opted for post-secondary studies.

In a survey 21 months after the completion of their studies, we found that two of these 26 students had obtained skilled jobs in a maintenance capacity, while three were employed as machine operators with maintenance responsibilities. Eight students were working as NC operators without any maintenance obligations, and seven as assembly-line workers. Of the remaining six, only two had jobs directly related to their qualifications.

In our opinion, the majority had obtained relatively unskilled jobs. Employers, in other words, had not utilised the competence conferred by the students' education.

Dissatisfied students

In connection with their recruitment for the Industrial Technology Branch, the students were told that industry was in great need of labour having exactly the qualifications which this industrial technology conclusion provided.

Consequently there was great disappointment when it was found that the majority did not obtain the jobs they had expected. Instead they were

offered ordinary assembly-line jobs without any maintenance responsibilities. Some of them then opted for post-secondary studies instead, while nearly all those who accepted jobs are keeping an open mind about going on to post-secondary studies after completing their military service. The students express their disappointment at industry being unacquainted with their education. This ignorance on the part of industry makes a stark contrast to the interest shown in the youngsters while they were studying. The ignorance, or perhaps one should say lack of respect, shown by industry towards education is clearly manifested when people have to undergo an in-house training programme at a much lower level than the school study programme, in order to gain access to a more advanced machine system.

It should be added, that most of the students had not intended working as operators with maintenance responsibilities but more intent on working in a maintenance department. Most of the students criticise the companies employing them, which in their opinion have failed to perceive the advantages of their education and, moreover, have not kept the promises made at the time when the pupils were recruited for the Industrial Technology Branch. Some students also feel that schools have helped to inspire them with "false hopes".

It is doubtful whether any conclusions can be drawn at all from the types of work obtained by the students after only 21 months. One has to bear in mind that many of these former Industrial Technology students are going through a species of "career phase" in which one can spend four or five years on relatively unskilled duties before being really "trusted" with more advanced ones. Perhaps their qualifications are really appreciated, though not in a way which they can notice and not with the rapidity they would like. These factors can be put down to misguided expectations on the students' part - exaggerated ideas of the rapidity with which they can get into exciting and well-paid jobs. Perhaps too we can invert the argument by saying that schools have succeeded in bringing up their students to be critical, impatient members of the community, not so easily "put in their place".

At the same time there is another, very important aspect involved here. If companies do not utilise the competence which students possess on

leaving school, is there any point in schools conferring that kind of competence? If companies do not immediately utilise the knowledge and skills possessed by the labour force when it arrives from school, it would probably be a better idea for companies themselves to confer the qualifications which will be needed in future.

It is a paradox that, at the same time as several big Swedish companies have been actively working to bring about the experimental Industrial Technology Branch, in at least one of these companies the students are very dissatisfied with the jobs they have been given.

Another factor which ought to be taken into consideration is that most of the youngsters we interviewed have not yet done their military service. Perhaps the employers are reluctant to give the "best" jobs to people who still have this period ahead of them. On the other hand we have not been able to see that the seven who have completed their military service have received more developmental jobs than their younger colleagues. Military service is also something of a watershed for the students. Many of them take the attitude that they will work until then but that afterwards they will turn their hands to something different.

Modern, computerised production technology

The study programme is aimed at conferring knowledge on the leading edge of production technology. To keep it up to date, continuous attention has to be paid to developments in industry and the labour market.

In our opinion, the Du-it programme is a modern one in terms of both study content and equipment, but this does not necessarily mean that it will be able to keep pace with the onward march of production technology.

As regards capacity for responding to the changing demands of industry and the labour market, the connection with the production technology centres means a great deal. If these centre activities turn out to be a success, they will be a dynamic resource capable of continuously supplying impasses for change in the study programme. In addition, it would be a good idea if co-operation with large-scale industry could be intensified. This, after all, is where new techniques are first put to practical use, and

this again is where the great majority of students have obtained jobs and will do so in the future.

Problem-solving and knowledge acquisition

The study programme as a whole is based on a concept in which problem-solving and knowledge acquisition are vital components. In our belief, this is also realised in the practical exercises performed by the students in the production technology laboratories. We believe that the modular thinking outlined by the ÖGY commission can in certain cases threaten this system-oriented holistic concept. Modularisation means delimiting and targeting part of a course or a teaching item.

There is an obvious risk that modular thinking, taken too far, will thwart the systematic approach and the holistic mentality so clearly expressed in the Industrial Technology Branch of the Production and Maintenance Engineering Line. The Industrial Technology Branch derives great benefit here from being a part of the Production and Maintenance Engineering Line. There is a tradition here of systematic thinking and a familiarity with teaching it.

The acquisition of systematic knowledge, as we see it, not a matter of developing skills according to a predetermined pattern but rather an iterative process in which the student himself, through his successes and failures, finds his own way to knowledge. This acquisition of knowledge can of course be facilitated by a certain amount of standardisation, but we believe the possibilities in this respect to be limited.

It is not our task to say how vocational education is to be organised in future, but in this connection we would like to point out the perils and limitations of standardisation. One solution is perhaps to "isolate" a number of lines from the rest of upper secondary school, allowing them to develop an alternative educational concept which, instead of standardisation, will represent holistic thinking and a systematic approach. It will then be up to industry to decide which people it wants to employ.

Flexibility and adaptability

Some companies, especially the smaller ones, point to the problem of students, on conclusion of their studies, not being familiar with their particular machines or operating systems. Larger companies do not look on this as a problem but expect to have to provide their own, more machine-specific training. Volvo Aircraft Engines, for example, has trained two employees in EDM (electrical discharge machining) because they will be working on machines of this particular kind. Saab trained electrical engineers at its Arlöv plant on a certain type of robot in connection with its installation.

At first sight, the production plant attached to the Industrial Technology Branch seems to imply a highly machine-specific form of education. And a great deal of the students' time is spent on this machine system.

In our opinion, though, this lack of generality in the education is more apparent than real. Generality exists at a higher, system-related level and is guaranteed by the education having a relatively large theoretical component and also by the system being so complex that anybody working with it is compelled to acquire a systematic way of going about things.

We believe it would be wrong to try to increase the generality of the programme by adding alternative machines and systems. There is in any case little chance of students being trained on the very machine or specific operating system which they will encounter subsequently in their working lives. Instead we believe that the main concern should be with the systematic handling of the equipment already installed.

Another aspect of the flexibility of this education is whether it has been constructed in such a way that it can be changed and adapted to changing realities. Here we find that, apart from the study programme being relatively theoretical, it has no such adjustment mechanisms. The expansive machinery may perhaps prove to be a strait-jacket. For example, can schools afford to keep it up to date? Suppliers believe that the mechanical components of the equipment will remain up to date for at least ten years, while the operating systems will have to be renewed much sooner. The teachers are more concerned, and they point to the absence of

write-off plans or other mechanisms ensuring that the equipment can still be kept up to date in future. The links existing between the study programme and the industrial technology centres existing in each of the surrounding communities may prove felicitous from this point of view, but this remains to be seen.

Another aspect of flexibility and adaptability is the occurrence of local variations. There is little variation between the different education centres. The machine line-ups vary in appearance, and Västerås in particular deviates from the other places, but even so the educational concepts are relatively identical. No doubt one important reason for this is the detailed regulations attaching to State grants, which run to about MSEK 2. Another reason is the detailed specifications included by the NBE in the service material drawn up by the planning group. Another standardising factor is the annual Du-it co-ordinating conferences, at which teachers have an opportunity of comparing notes.

Du-it - a study programme for the industrial employment of tomorrow

In view of the developments which have now been described, we believe the study programme of the Industrial Technology Branch of the Production and Maintenance Engineering Line to be closely attuned to the present and future labour requirements of the engineering industry. The Industrial Technology Branch deals with modern technology at a systematic level relevant to the future, and it fulfils express wishes for the integration of electrical engineering and mechanical engineering competence in one and the same study programme.

What is perhaps lacking is a more perceptible link with the ideas of group work organisation which so obviously permeate Swedish industry. Working life based on group organisation requires a labour force with some training in administrative and economic routines. It also requires a knowledge of problem formulation and problem solving. The latter should be attainable in connection with laboratory work using the production equipment provided for the study programme. The thing then is to safeguard creative potential and not to give into the temptation of excessively pre-programming laboratory activities.

Finally, the study programme does not include any elements relating to the quality of the products manufactured. We believe that quality questions are destined to occupy a more prominent position than ever in the factories of the future, and that this should be allowed to leave its mark on a study programme of the kind we are here concerned with.

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